"Control of DC-DC Converter for PV System using Artificial Intelligent Technique"

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna International Institute of Research and Studies

(Deemed to be University)

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Certificate

I hereby declare that the short synopsis **"Control of DC-DC Converter for PV System using Artificial Intelligent Technique"** being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Electrical and Electronics Department under faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2018-2019

It is a bona fide record of original work carried out under the supervision of Dr. Anita Khosla & Joint-Supervisor Dr. Dheeraj Joshi and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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Abstract

Abstract

With the depletion in the fossil fuels ,renewable energy sources are gaining utmost importance. Among sustainable energy sources, photovoltaic (PV) energy has become the vital part of energy mix .This ignite is due to reduced cost of PV panels with the advancement in the field of power electronics. The output obtained from the solar panel is low power DC which is required to be converted into the desired level for the industrial applications using suitable converter. There are various different topologies of the converters available each with its own implications and limitations. . In this research the different existing converter topologies will be analyzed and then one with the optimum performance will be found. The primary aim of the research is to design and analyze PV based DC-DC converter topology and its optimal intelligent control technique. The understanding obtained from primary aim shall be used in the industrial applications as a cost effective, efficient power source.

Key words: Renewable, Photovoltaic , DC-DC converter, Intelligent technique.

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1.Introduction

The steep augments in the demand in the era for the clean energy sources and better & efficient method of energy conversion has led to the advancement in the field of converter technology accomplished with the natural resources. There are numerous natural energy resources like solar ,wind ,bio, geothermal etc. which are being utilized in power generation in the recent years. The renewable energy resources are helpful in reducing the effect of global warming has they have less CO2 emission. The solar energy is gaining importance in this field as it is available in abundance in India .Also due to the advancement in power electronics technologies the cost of photovoltaic (PV) panels had reduced drastically which had resulted in popularity of solar PV system. This system generates electric power by converting sun irradiation into direct current .The generation of power using PV system employs solar sheets and then by connecting in series or parallel constitute a PV module. Further these PV modules are combined for the high power applications. There is the requirement of optimal operation of PV systems because efficiency of the output from the solar panel is low. The nonlinear characteristics of PV systems is the consequence of varying ambient temperature and solar insolation (Abdulkadir,Samosir &Yatim 2012). Therefore algorithm for tracking the utmost power is crucial to acquire "Maximum Power Operating Point(MPPT)" and fed to the load. "DC-DC converter" act as bridge between module and load for transferring the power . To locate the operating voltage and current at which the highest power is obtained under given warmth and irradiance is chief goal of MPPT. The most extreme power is got by altering the obligation cycle "DC/DC Converter". There are different algorithms for tracking maximum power like perturbation & observation, incremental conductance, constant voltage algorithm, hill climbing technique, fuzzy logic, neural network and it will automatically trace "irradiance and temperature" but some are more specific for temperature. Though there are chances of having multiple local maxima in case of effect of partial shading yet in general there is just a single true peak power point. The heart of the photovoltaic system is MPPT techniques which are dependent on the power converter. There are various converter framework each having its own implications and limitation. The basic property of these converters are that degree of control over its output voltage is achieved by altering on-off time of the converter. Thus by changing switch drive ratio, converter can be controlled. The isolated or non-isolated topologies are the categories of the DC-DC converters (Ajami,Ardi

&Farakhor 2015). In isolated topologies insulation transformer of high frequency is used in between input and output and desired operation is achieved. The flyback, half-bridge, and full-bridge converter are the basic isolated converter topologies that are used in major applications. In solar PV applications, isolated converter is used for grid tie system in order to provide more safety.

No transformer is being used in non isolated converter topologies and these converter are used in DC motor drives.Non Isolated framework are further discriminated as buck ,boost ,buck boost converter. Buck converter trim down the voltage ,used in charging the battery in PV applications. To step up the voltage, boost converters are used which increases the voltage level before the inverter stage in grid tied systems (Cuk et al.1983). To increment or decrement the voltage level circuitry like "buck-boost,cuk, single ended primary inductor Converter(SEPIC)" are used(Lee et al.2016) .In PV systems having batteries ,for almost combination of irradiance and temperature. Buck converter can't work when the MPP goes underneath the battery charging voltage under a low-irradiance and high-temperature condition, else it can work at MPP. Thus there is a need of additional boost capability to improve the proficiency of the converter .Switching loss in the converter can be decreased by incrementing the toggling frequency but it effects the efficiency of the converter. By using resonant converter switching loss can be reduced. The soft switching techniques can be applied to the converter which enables soaring frequency operation and condense in the dimension of the converter. Photovoltaic systems are gaining importance in electric vehicles, irrigation purpose, grid tied system etc (Abu-Aligah 2011). Solar photovoltaic pumping systems are more effective than other traditional water siphoning frameworks .Both DC& AC motors can be used in water driving systems. But it is advantageous to use DC motors as it can be directly coupled with the solar panel, in case of AC motors there is the need of Inverter which will increase the size and cost. But the pumps having more than 7KW generation AC motors are preferred (Acakpovi et al. 2012). Nowadays, "Brushless DC motor" are preferred for low power applications as it reduces the maintenance costs and increases the reliability and life span.

2.Literature Survey

Literature presents several DC-DC Converter topologies available for the industrial applications. The one aim of these converter is to feed the appropriate voltage to the industrial applications. In

last years various researchers analyzed the different topologies .The design aspects of "DC-DC converters" are studied (Biswal & Sabyasachi 2012) in the paper . The basic classification are Buck and boost types which are simulated by the authors .Consideration for choosing the appropriate filter is studied by the presenters.

Dual input "DC-DC converter" is analyzed by the authors(Athikkal et al. 2018)which is used as the interface converter. examination of the different modes such as buck ,boost ,buck-boost type converter is investigated by the authors. the effect of the effective series resistance is also being considered. This converter with the hybrid mode is finding relevance in the industries.

In order to provide high voltage gain a "bidirectional switched capacitor dc–dc converter" is used proposed by(Qian *et al*.2012) .A novel converters was projected which has with the prospective of high voltage gain and it is evaluated with counterpart i.e "switched capacitor dc–dc converter" .it has less power loss ,reduces total capacitor voltage ratings;less number of switching devices , less current flowing through device ,high efficiency and lowers cost; allows bidirectional operation; appropriate for elevated-voltage gain appliances.

The conduct of diverse "maximum power point tracking (MPPT) techniques" applied to PV systems was discussed by (Rezk & Eltamaly 2015). They examine the procedures "Hill climbing, gradual conductance ,Peturb & Observe (P&O), and Fuzzy logic controller(FLC)" . The PV system model with the "DC-DC converter" employing diverse MPPT was mimicked utilizing PSIM and Simulink programming by the creator . Co-reproduction among PSIM and Simulink programming bundles is utilized to set up FLC MPPT method was likewise done in this paper.

In high output voltage requirement, the positive output super lift converter are proposed by (Tekade et al. 2016) which is based on the voltage lift technique that increase the voltage by geometric progression .these are gaining importance in high voltage application as such as electric vehicles. Luo converter are classified according to the number of the elements used and complexity of the network. Elementary, re-lift and triple lift topologies are analyzed and simulated in the matlab environment. Theoretical and simulated results of the output voltage are also being compared in this paper.

Renewable energy source based Luo converter is being presented by the author (Nath & Jayarama 2016).Improved positive output super lift Luo converter (IPOSLC) with photovoltaic source lift the voltage by geometric progression. the author compared conventional super lift luo converter with IMPOSLC and found that in this voltage is increased six times of the input as compared to the conventional one in which its only three times. Peturb & observe algorithm for maximum power point tracking is applied for calculating the duty cycles of the converter. The model is simulated in matlab simulink and validated using the theoretical values.

Self lift Luo converter is implemented by (Raghuveer et al. 2018) in this paper. The converter is based on the solar source .In order to extract the highest power maximum power point is employed which is based on the PID controller and the particle swarm optimization technique is used by the authors for the optimization for calculation of duty cycle.

The particle swarm optimization algorithm which is improved frog leaping is applied for calculating the duty cycle based on the maximum power point tracking method by (Nie& Nie 2017 **)** .This swarm intelligence algorithm (SIA) has high computation capability.SIA base MPPT control techniques are gaining advantages nowadays. In order surmount the defect of falling into partial optimal solution and less speed of convergence ,the standard SFLA was modified by adding the inertia weight constant of PSO to proposed the new algorithm PSFLA .the method was proposed to reduce the effect of noise under the complex environment on MPPT by combining PSFLA with recursive least square filtering .

A modular grid associated photovoltaic (PV) framework to improve the effectiveness and dependability for dispersed micro generation and comprises of dc– dc converters and dc– ac inverters was proposed (Zhang *et al.* 2011). The creators talked about the key issue of ac current pairing between the parallel-worked inverters. A current-decoupling technique was proposed and actualized by controlling the flows of split-filter inductors, separately. Ideal control methodology for the efficiency upgrade of PV framework by using the scattering of control parameters was proposed.

Analysis of Elementary topology of Luo DC –DC converter in its voltage control mode for the application like electric vehicle is done by (Navamani et al. 2015).to evaluate the ripple voltage ,output voltage gain, effect on switches and efficiency the comparative analysis of all the series

of super lift luo converter is done by the authors. The optimum converter is found and modeled using the state space averaging technique is done and transfer functions are calculated in this paper.

The positive output luo converter and negative output luo converter by using the integrated hybrid topology is presented in this research (Sujatha,Chilambarasam & Babu 2015). By using the two sources , the uninterruptable, power supply is obtained , efficiency & reliability of the converter is enhanced. The fused Luo converter has the capability to filter out the high frequency harmonics, provides less ripples in the output voltage due to its inherit feature and hence there is no need of additional filter circuit . Thus the proposed topology has reduced cost and size.

A water pumping system which uses switched reluctance motor (SRM) drive is presented in the paper(Singh & kumar 2015). The modeling of the water pumping system which uses Luo converter is modeled and simulation is done in Matlab. The converter is fed by the solar source and its performance under different insolation level is being studied in the paper. In continuous current mode the luo converter resulted by the less stress on the switches at high frequency. It helps in the soft starting of SRM drive and reduced switching loss. The increment & Conductance technique for the MPPT is proposed.

The conventional DC-Dc converters are affected by the parasitic elements due to which the ripples are produced in the output voltage and it is undesirable for the applications like electric vehicle .So the authors(Manikandan & Vadivel 2013) proposes luo converter for electric vehicle applications. This converter is based on voltage lift technique and boost the voltage to the higher level. The extra elements connected in such a way so that the output produce is ripple free ,which is desired in industrial applications.

The boost converter in its continuous current mode with feedback controller is presented by the authors (Abdelgawad & Sood 2016). The controller of the converter is optimized to achieve the desired performance. The PSO is used for the tuning of the PID controller which is used for the feedback control. The small signal modeling is done for the converter to obtain the objective

function for the PSO. The Ziegler Nicholas tuning is also done on PID to compare it with PSO and validate the performance of the converter.

The modeling of the PV module is done by the authors(Bellia,Youcef & Fatima 2014) . This model represents the PV module under all changing conditions which illumination and temperature. it has the capability to determine the parameter under the different temperature and insolation. This modeling can be applied to the any of the PV module available in the market and can be used as the tool for determine the parameters.

The researchers (Nejabatkhah et al. 2011) proposed a "three-input dc– dc converter" which interfaces "two unidirectional in ports" and "a bidirectional port" for a capacity component in a framework. This converter is intriguing for hybridizing elective vitality sources, for example, "photovoltaic(PV)source, fuel cell (FC) source, and battery". The proposed structure uses power switches employing duty ratio control.

The authors (Hua et al. 1998) research the MPPT calculations frequently employed to look at the tracking competence for the framework working under various controls. Plus, various sort of DC/DC converters were intended to assess the converter execution. A basic strategy which joins a discrete time control and a PI compensator is utilized to follow the maximum power points (MPPs) of the solar based cluster. The proposed converter framework usage depended on a computerized signal processor .

The researchers (Sun et al. 2011) proposed conveyed control technique dependent on enhanced DC bus conditioning for photovoltaic(PV) framework with storage. The authors depict the synthesis of modular PV generating system includes three "DC-DC converters" for photovoltaic exhibits, two matrix associated "DC/AC converters", one "DC/DC converter" for battery charging/discharging ,neighborhood loads accessible for either grid associated activity or islanding .The authors further classified the tasks of particular PV generated framework into four modes: islanding with battery releasing, rectification, inversion and islanding with steady voltage generation. Control techniques for "DC/DC converters, battery converter and grid associated converter" are additionally focused

3.Gaps Identified

The recent electronic systems demands for the efficient ,reliable, light weight power supplies. Earlier power supplies uses linear regulators in which are based on the voltage division

principles but their efficiency is low and output voltage range is limited . Switching regulators which uses the semiconductor device in its on and off modes will be more appropriate for better performance as their efficiency is high as compared to the linear regulators . To achieve the high conversion ratio , switching frequency need to be increased. But by doing this switching losses tends to increment which reduces the overall efficiency. Thus there is the need of the efficient controller.

Performance of Conventional DC-DC converter are effected by inherent parasitic elements of the semiconductor switches used. Due to this efficiency of the converter is reduced and ripples are produced in the output voltage(Han,Lee&Kim 2018).The energy dissipated by the parasitic elements causes heating and extra thermal stability is needed to compensate this.

Renewable energy sources are gaining importance as natural resources are depleting and there is a demand of green energy so as to reduce the effect of co2 emissions. It is desirable to use Solar energy as the prominent source as it is available in abundance. Due to the changes in environmental conditions there are the changes in temperature and irradiation level of the Solar energy and hence the power generated from the PV modules. There is the need of the efficient ,robust and cost effective controller that will track the position of the Sun to extract the maximum power .

Feedback control of the system is necessary to obtain the desired results. There are various controller like PI,PID,Fuzzy,neural that can be used for the purpose . But to make the controllers work effectively it is essential to optimize these controllers by using optimal algorithm so as to obtain the desired performance of the system.

4.Description of Broad Area

The demand of energy will be increasing at rapid rate with increase in population in coming decades .Also the usage of the electrical energy need will also grow at same instant. According to the previous research substantial amount of electrical energy is being exploited by the usage of motors in numerous industrial applications. Fossil fuels are going to be depleted in the near future and also they have negative effect on the surrounding which has increased the effect of global warming as emission of CO2 gas is one of the major concern and has an effect on the environment stability. It has become important so as to save the environment to switch towards green energy. The renewable energy source are available in abundance such as solar, wind but the important issue is to use these sources efficiently (Subidhi&Pradhan 2013).

The solar energy is gaining importance in this field as it is available in abundance in India .Also due to the advancement in power electronics technologies the cost of PV panels has reduced drastically which had resulted in popularity of solar PV system. The solar Photovoltaic system generates electric power by converting Sun irradiation into direct current .The generation of power using PV system employs solar panels constituting solar cell connected series or in parallel form PV module. Further PV units combined for the high power applications (Alireza& Asghar 2013). There is the requirement of optimal operation of PV systems because the efficiency of the output from the solar panel is low (Amrani 2013). There is the effect of shifting "ambient temperature" and "solar irradiance level" on the nonlinear characteristics of "PV systems". "Maximum power tracking technique" is required to obtain maximum power operating point from a PV system in changing condition and transferring that output into the load (Zainudin & Mekhilef 2010). A DC/DC converter go about as interface between the module and the heap for exchanging the power. The principle objective of MPPT is to discover the voltage working and working current at which greatest power is gotten under given temperature and irradiance. By adjusting the duty cycle of the interface which is "DC/DC converter" the maximum power is obtained. There are different algorithm for tracking maximum power like perturbation & observation, Incremental conductance, constant voltage algorithm, hill climbing technique, fuzzy logic, neural network . All the systems would consequently react to the progressions both in irradiance and temperature yet some are more explicit for temperature. in spite of the fact that there are the odds of having numerous nearby maxima if there should arise an occurrence of impact of incomplete shading yet by and large there is just a single genuine pinnacle control point. The heart of the photovoltaic system is MPPT techniques which are dependent on the "DC-DC Converter". The various "DC –DC converter" topologies each having its own implications and limitation(Kim et al. 2017). The basic property of these converter is that degree of control over its output voltage is achieved by varying the time ratio of the converter. thus by changing switch drive ratio converter can be controlled. The DC-DC converter topologies(Tseng et al.2014) are classified into isolated or non isolated topologies. In isolated ,transformers are used to provide the isolation by altering the turn ratio step up or step down operation is achieved. This solar photovoltaic (SPV) generated electrical energy for numerous applications as far as possible. The one of the application gaining the importance is the standalone solar power based water pumping application in the field of irrigation, household and

industrial applications (Abarnaa& Bhavani 2014). There is numerous researches which is being carried out in this era. The major part is played by the "DC-DC converters" in photovoltaic based applications .These converters are further divided into six generations ,each one differ with the feature up to which extent the DC voltage is altered . Sizing the photovoltaic system is also the one of the task which is to accomplished by using the software package . It helps to increase the efficiency of the system by using the appropriate technology and supports in the economic analysis.

5.**Problem Identification**

The power supplies forms the core of the any electronic system. to obtain the efficient supplies switch mode regulators are gaining the importance. The switching devices of these regulators work at high frequency. There are numerous topologies of the Dc-Dc converter but the basic are buck,boost,buck-boost . Other topologies are derived from the basic ones. Though these supplies work better than the linear regulators but the conventional topologies are affected by the inherent parasitic property of the semiconductors which diminishes the overall voltage gain. Advanced converters are free from the effect of parasitic element and lifts the voltage by sufficient amount .The efficient DC-Dc converter topology will be designed in the research. This converter is used in the solar powered application as the output of the PV system is low and it needs to be boosted for the industrial applications. Closed loop control of the converter will be projected in the research and optimized controller will be applied for the desired performance.

6. Objectives of Research

The objectives of the research work are stated as follows:

1. To Survey of the present DC-DC converter topologies.
2. To analyze, simulate and implement Photovoltaic(PV) based DC-DC Converter .
3. To develop the artificial intelligence controller for DC-DC converter .
4. To optimize the controller by using optimization technique.
5. To analyze the photovoltaic based converter for the Industrial application using software package.

7. Methodology to be adopted:

Following procedure will be adopted to carry the research

1. Modeling & Simulation of the existing conventional topologies of the DC –DC converters.
2. Development of the modified DC-DC Converter topology.
3. Simulating the converter in the closed Loop Control model.
4. Applying the Converter to boost the voltage output of the photovoltaic source.
5. Development of the appropriate optimal control algorithm.
6. Analyze the converter for the industrial application.

8. Expected outcome of the research

1. The first outcome of the research will be the design of the efficient solar based DC-DC Converter with low cost, reduced switching loss and smooth output.
2. The second outcome of the research will be the development of comparison MPPT technique that will be able to track the maximum power under the environmental changes.
3. The third outcome of the research is the Analysis of PV based DC-DC converter for the industrial purpose.

9.Proposed time frame

Time Frame	Dec 16-June 17			July-Dec 17			Jan -June 18			July-Dec 18			Jan-June 2019			July-Dec 19			Mar 2020		
Months	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	37	38	39
Course Work	■	■	■																		
Extensive Literature Survey		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Problem Statement		■	■	■	■																
Modeling of Solar DC-DC Converter					■	■	■	■	■												
Simulation of DC-DC Converter using MPPT								■	■	■	■	■									
Using Solar PV System for Industrial Application												■	■	■	■						
Optimization of PV system using software package													■	■	■	■	■	■			
Analyzing optimum control technique of the application														■	■	■					
Publication Related to the work											■	■	■	■	■	■	■	■	■	■	■
Detail Writing and submission report																		■	■	■	■

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